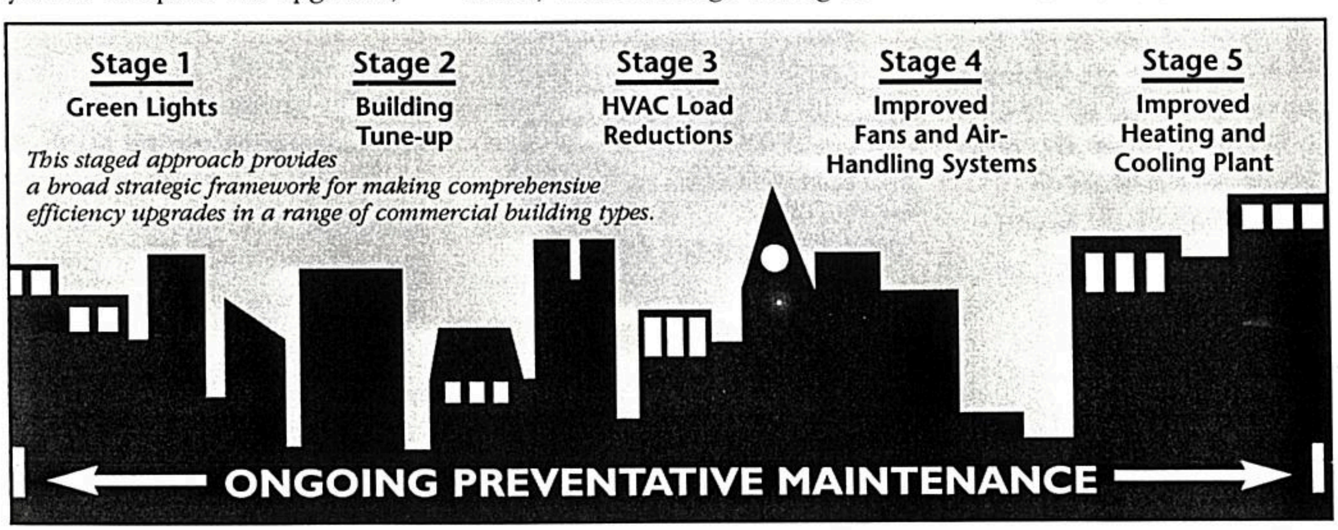
Introducing the Energy Star Showcase Buildings Series

With the introduction of the Energy Star Showcase Buildings initiative on June 16, 1994, the U.S. Environmental Protection Agency laid the groundwork for the expected 1995 launch of the Energy Star Buildings program—a staged approach to achieving comprehensive, energy-efficient upgrades in commercial buildings. To share the progress of these Showcase projects, the *Update* will feature a monthly column that reports on the results of the Showcase Buildings participants as they implement each stage of the program.

In 1994, 24 Green Lights participants agreed to join the Energy Star Showcase Buildings initiative by committing one of their facilities (representing a cross-section of building types throughout the country) to serve as a case study for this staged-approached program. With 1 year to complete the upgrades, each Showcase Buildings participant will aim to implement each of the program's five stages one at a time, evaluating each stage's impact on energy savings before proceeding to the next step. EPA expects that participants will realize savings of up to 40 percent in overall energy usage while achieving an internal rate of return of at least prime rate plus 6 percent.

Like Green Lights, the Buildings program will be a voluntary partnership between EPA and private and public institutions to reduce energy usage and, thereby, air pollution associated with electricity generation. Although the Buildings program will follow the same profit-based strategy as Green Lights, the program utilizes a broader scope of energy-efficient upgrades. Each of the program's five stages (outlined below) serves as a building block, with one stage having an impact on the implementation and results of succeeding stages. For example, it is rarely economical to upgrade the HVAC plant (Stage 5) unless significant effort is made in prior stages to reduce cooling load.

To document energy savings at each step, a special measurement and verification process has been set up. Documentation includes building baseline energy use segmented by major loads. Peak energy use by load and peak air-conditioning cooling loads are also measured. The March *Update* will elaborate on the measurement and verification process. To learn more about the Energy Star Buildings and Showcase programs, call the Green Lights/Energy Star Hotline at 202 775-6650.



The Energy Star Showcase Buildings Series: Measurement and Verification

To help Green Lights participants follow EPA's Energy Star Showcase Buildings initiative (launched June 16, 1994), the *Update* is documenting the results of Showcase Buildings participants as they implement each stage of the program. This article, the second in a series, describes the special measurement and verification process being used at each Showcase site to:

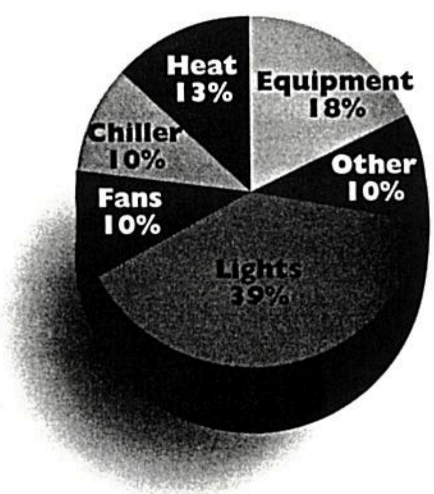
- Help Showcase Buildings Partners effectively identify major energy savings opportunities
- Ensure that the Showcase Buildings serve as solid case studies for the Energy Star Buildings program
- Set guidelines for monitoring Showcase Buildings results to produce consistent, practical data for program use
- Minimize the cost of Energy Star Building monitoring by relying largely on energy management systems that already exist in buildings

The target for Energy Star Buildings is a 40 percent reduction in energy loads. The measurement and verification process establishes a baseline energy use profile segmented by major energy loads.

While utility bills can be used to assess a building's overall baseline energy use, they do not typically reveal potential energy savings. Electric and gas bills do not break down energy usage by end use and do not include data on important load-influencing factors, such as heating and cooling degree days. In addition, a complete 3-year record is generally necessary to accurately analyze electric and gas bills—data sets that are not always easy to obtain.

To achieve a more accurate profile of a building's energy use, it is useful to document energy use segmented by the following major loads: air handling; lighting and lighting panels; cooking equipment; computer data center; receptacle (plug loads); and heating/reheating and cooling equipment.

Sample Energy End Use Profile



On-site metering equipment can record energy used by specific loads. For example, recording meters attached to air handler motors can determine the actual amount of energy required to move air to various areas of a building. By also recording and analyzing weather conditions in conjunction with metering, an accurate assessment of the building's systems and energy efficiency can be made.

While this level of sophistication for measuring and verifying will probably not be required when the full-scale Energy Star Buildings program is launched, potential participants will benefit from the detailed monitoring used in the Showcases.

The April/May *Update* will take a closer look at the implementation of Stage 1: How Green Lights optimizes benefits from the Energy Star Buildings program. To learn more about the Energy Star Buildings and Showcase programs, call the Green Lights/Energy Star Hotline at 202 775-6650.

CLARIFICATION: *In the article regarding the new 20 percent IRR requirement that appeared in the January/February* Green Lights Update, *both Options 1 and 2 are winners. While Option 2 produces a higher IRR, Option 1 does meet the minimum IRR required, and it produces greater kilowatt-hour/year savings than Option 2. EPA regrets any misunderstandings this may have caused.*

SHOWCASE BUILDINGS

GL: First Step to Total Building Efficiency

BUILDINGS

Stage 1: Green Lights

To help Green Lights participants follow EPA's Energy Star Showcase Buildings initiative (launched June 16, 1994), the Update *is documenting the results of Showcase Buildings participants as they implement each stage of the program. This article, the third in a series, describes Stage 1: How Green Lights optimizes benefits from the Energy Star Buildings program.*

In commercial buildings, lighting typically consumes up to 40 percent of the total energy used, and Green Lights upgrades can produce lighting loads by as much as 75 percent. However, lighting systems do more than just convert electricity to light. Lights generate heat, and inefficient systems generate more heat than energy-efficient ones.

Lighting systems therefore affect heating, ventilating, and air-conditioning (HVAC) systems, increasing the cooling necessary to keep a building comfortable. One kilowatt of lighting load produces almost one kilowatt of heat (3,413 BTUs) — so using fewer watts for lighting reduces electricity used and heat created. As shown below, Green Lights upgrades installed by Energy Star Showcase participant **Mobil R&D** are producing annual energy cost savings of $42,000 and reducing the cooling load by 45 tons. This reduction in cooling load saved Mobil R&D $18,000 when they bought new chillers. In addition, Mobil R&D is saving $8,700 a year in cooling costs due to Green Lights upgrades.

Green Lights upgrades allow Energy Star Buildings to take fuller advantage of HVAC upgrades, including:

- Installing variable speed drives (VSDs);
- Reducing fan motor sizes; and
- Downsizing chillers, while maintaining cooling comfort for peak loads.

Without the cooling load reductions from Green Lights upgrades, many HVAC upgrades are far less profitable or are ineffective. Even though installing the most energy-efficient lighting will increase initial lighting upgrade costs, the extra HVAC savings will often offset this increase. The annual energy cost savings shown below indicate the role Green Lights upgrades can play in Energy Star Buildings.

The June *Update* will take a closer look at Stage 2: Building Tune-Ups. To learn more about the Energy Star Buildings and showcase programs, call the Green Lights/ Energy Star Hotline at 202 775-6650.

Implementing Stage 1

Three Showcase Buildings

Participant	FANNIE MAE	Mobil R&D	Connecticut Mutual
Square Feet	250,000	340,000	484,000
Lighting Upgrade Costs	$375,000	$210,000	$343,000
Annual Lighting Cost Savings	$85,000	$42,000	$147,000
IRR	23%	20%	43%
Net Present Value (NPV)	$261,000	$107,000	$755,000
Annual Lighting Energy Savings (kWh)	1.3 million	1.2 million	2.0 million
Electricity Load Reduction (kW)	221	112	223
Cooling Load Reduction (tons)	33	45	50
Potential Cost Reduction of Cooling System Upgrades**	$20,000	$18,000	$26,000
Annual HVAC Cost Savings due to Lighting Upgrades (operation)	$15,300	$8,700	$8,600

**This cost reduction is a result of Green Lights upgrades.

ENERGY STAR BUILDINGS

Tuneups Make ES Buildings Run Better

Stage 2: Building Tuneup

To help Green Lights participants follow the ENERGY STAR Buildings program, the Update *is documenting the ENERGY STAR Buildings five-step process and highlighting the results of Showcase Buildings participants as they implement the program. This article, the fourth in a series, describes Stage 2, the Building Tuneup.*

Like a car, buildings need to be tuned up periodically, and like a car tuneup, a good building tuneup can make the building run better. The building tuneup includes checks such as:

- Are filters and strainers in good condition?
- Are air handling units and cooling equipment turned off when associated zones are not occupied?
- Are free cooling opportunities (economizers) being fully utilized?
- Have thermostats have been calibrated within the last year?
- Are the sequences of operation correct for heating and cooling equipment, and are site personnel trained to operate equipment to reduce energy costs?

The tuneup basically tries to get the building to operate close to the way the designer originally intended. This process is sometimes referred to as recommissioning. A helpful side effect of the recommissioning/tuneup process is that it often uncovers things about the building that were never anticipated during the original design. For example:

- After a Green Lights upgrade, less waste heat is given off by the new lighting. Therefore, a building manager may find that less cooling is needed for parts of the building, so cooling air temperatures can often be set higher, and energy is saved.
- The air conditioning system for a space may have been set to handle the heat from 100 people in the space, but if 100 people never use the space, it may be helpful to reduce the supply of cold air.
- In a different room, a large photocopier may have been added without adjusting the cooling air available to the room, so the air flow needs to be increased.
- To be safe, a designer may have provided hot water to heat a building during certain months of each year, but during the running of the building some of those months did not require heat after all. During the tuneup process, hot water pumps can be set to turn off during those months, and in some cases boilers can be turned off as well.
- Is the amount of outside air appropriate? Sometimes dampers should be adjusted to keep from heating and cooling excess air. In other cases dampers should be opened more to help provide adequate ventilation.
- Because of their age, many control systems are in need of adjustment, repair, or upgrade. During the tuneup it is a good time to evaluate whether modifications should be made to enhance the degree of control of the heating and cooling systems.

One of the most important aspects of the tuneup is that, like other ENERGY STAR stages, it has a ripple effect on the later stages. A tuneup will often reduce cooling loads. This often lowers the cost of fan and plant upgrades because, together with the impact from Green Lights and Stage 3 load reductions, lower cooling loads can translate into smaller variable speed drives on fan systems and smaller chiller replacements. Tuneup measures are often the most cost effective changes to a building, and sometimes provide big savings. In the Montgomery County Showcase building, for example, the tuneup alone reduced energy use around 28 percent.

The July *Update* will take a closer look at the implementation of Stage 3: Load Reductions. To learn more about the ENERGY STAR Building and Showcase programs call the Green Lights/ENERGY STAR Hotline at 202 775-6650.

ENERGY STAR BUILDINGS

HVAC Load Reductions Lower Energy Bills

Energy Star Buildings Stage 3: HVAC Load Reductions

To introduce Green Lights participants to the ENERGY STAR Buildings program, the Update *is documenting the results of Showcase Buildings participants as they implement each stage of the program. This article, the fifth in a series, describes Stage 3: HVAC Load Reductions.*

A central goal of the ENERGY STAR Buildings approach to comprehensive energy upgrades is to reduce heating and cooling loads as far as profitable before tackling the HVAC equipment upgrades covered in Stages 4 and 5. By reducing loads first, it often becomes possible to replace existing chillers, for example, with smaller, more efficient units that provide an attractive return on investment.

Stage 3 finishes the HVAC load reductions that Green Lights (Stage 1), begins. Beyond the waste heat that lighting produces, and which Green Lights reduces, there are two main types of building cooling loads—waste heat from office equipment and unwanted heat gain through the windows and roof of a building.

Office equipment, such as computers, printers, fax machines, copiers, cooking and other miscellaneous loads, can consume as much as 20–30 percent of the electricity used by a facility and add to the building cooling load. Fortunately, the use of new energy-efficient office equipment can reduce this category of energy use by up to 50 percent and in the process reduce the cooling load

EPA's ENERGY STAR Office Equipment program is devoted to increasing the use of energy-efficient computers, printers, fax machines and copiers in commercial offices. The energy-efficient equipment, labeled with the EPA ENERGY STAR Pollution Preventer logo, can cut energy use in half. This and other ENERGY STAR programs are simple voluntary purchasing agreements whereby the organization agrees to purchase ENERGY STAR labeled equipment when replacing units. Organizations can join the ENERGY STAR Office Equipment program by signing a simple voluntary purchasing agreement.

ENERGY STAR Showcase Building participant, Mobil R&D, is saving $3,000 annually by replacing the first 15 percent of their older computers in one year with ENERGY STAR Computers. Mobil's ENERGY STAR Computers will also reduce the building's cooling load by five tons when fully implemented.

The other opportunity for reducing building cooling loads is by upgrading a building's envelope or exterior, such as improving roof insulation, window solar gain, and air leakage. Upgrading roof insulation is often cost effective during scheduled repairs. Improving the roof insulation and fixing air leaks will often produce substantial energy savings, but upgrading the windows can have an even larger impact.

Have you ever wondered why, even in the dead of winter with the temperature hovering below freezing, that your car sitting on an open parking lot in the sunshine can be so snug and warm, even when you have been gone for some time? Solar radiant energy is a powerful heat source. Consider how much heat would be necessary to heat your car when the temperature outside is in the 20's; then imagine what the summertime solar load on a glass building would be. When designing a building the consulting engineer has to set aside a significant part of

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the cooling capacity just to offset solar radiant heat gains.

The most profitable window upgrade is generally the application of window film to the inside of the glass. Window film is a metallic-based polyester film that reduces the solar heat gain from the outside and reduces the loss of internal heat through the window when it is cold outside. Therefore, the sun's heat is kept out during cooling season and heat is kept in during the heating season, providing a good return on investment through lower energy costs. Besides saving energy and money, window films can improve the appearance of a building by making all windows appear uniform. The Mobil facility in Reston Town Center is installing window film and will save $10,000 annually as well as reducing the cooling load by 35 tons.

Stage 3 upgrades result in cooling load reductions that, when combined with earlier reductions from Stage 1 and Stage 2, can provide a significant opportunity to downsize the HVAC equipment. Thus, Stage 3 allows the ENERGY STAR Building to make HVAC equipment upgrades more profitable, both through lower up-front equipment costs and through savings on energy bills made possible by lower cooling and heating loads.

The August *Update* will take a closer look at Stage 4: Improved Fans and Air Handling Systems. To learn more about the ENERGY STAR Buildings program, call the Green Lights/ENERGY STAR Hotline at 202 775-6650.

ENERGY STAR BUILDINGS

Profitable Investments in Building Upgrades

Stage 4: Improved Fans and Air-Handling Systems

To help Green Lights participants follow EPA's ENERGY STAR *Buildings initiative, the* Update *is documenting the results of the Showcase Buildings participants as they implement each stage of the program. This article, the fifth in a series, describes Stage 4: Improved Fans and Air-Handling Systems.*

Fan motors in air handlers can account for as much as 20 percent of the energy usage in commercial buildings. There are several opportunities that can significantly reduce energy consumption by increasing fan system efficiency. Improving fan systems and air distribution is often one of the most profitable investments a building owner can make when upgrading the performance of a building.

In this fourth stage of the ENERGY STAR Buildings process, the payoffs of implementing Stages 1, 2, and 3 are evident. Building tuneups (Stage 2) assure that equipment upgrades in Stages 4 and 5 are applied to properly functioning equipment. Also, by implementing Green Lights (Stage 1), tuning up the building systems (Stage 2), and reducing additional building HVAC loads (Stage 3), building owners can significantly reduce the size and cost of mechanical equipment upgrades in Stages 4 and 5.

After Stages 1, 2, and 3, many of the fans will be larger than necessary to handle the reduced loads. Excessively "oversized" fan systems not only waste energy, but also increase noise levels, and cause greater wear on equipment. Oversized fans are ideal candidates for variable speed drives and motor downsizing. This is a powerful example of the ENERGY STAR Buildings approach, which is to maximize energy savings and lower the costs to perform upgrades. Four actions should be considered to save energy and correct fan oversizing:

1. Larger fan pulleys: An existing fan pulley often can be replaced with a larger fan pulley, which will reduce air flow by reducing the fan speed. Reducing a fan's speed by 20 percent reduces its energy requirements by about 50 percent.

2. Energy-efficient motors: Compared to standard motors, energy-efficient motors use 3-8 percent less energy, are more reliable, and generally have longer warranties. Replacing existing motors with new energy-efficient motors can reduce maintenance costs and can postpone or eliminate the need to expand electrical supply systems.

3. Variable speed drives: Variable speed drives (VSDs) save energy by electronically controlling the speed and torque of the motor to satisfy changing system loads. The only power consumed is the power required to meet the load. Under part-load conditions, a VSD will reduce air flow by reducing fan speed, which is far more efficient than running the fan at full speed and reducing air flow by partially closing a damper. VSDs save energy since the power consumed is proportional to the cube of the air flow. For example, if the air flow is reduced by half (a factor of two), the fan power consumption is reduced by approximately a factor of eight.

ENERGY STAR Showcase Building participant Mobil Corporation installed 21 variable speed drives in its research and development facility in Dallas, TX. These upgrades were very profitable, saving approximately $105,000 annually, with an internal rate of return (IRR) of better than 40 percent. This IRR translates into a simple payback of slightly more than two years. The table below shows the results of selected ENERGY STAR Showcase Buildings participants.

4. Duct static pressure: The duct static pressure of a fan system is based on 100 percent design air flow. After load reductions in Stages 1 through 3, the fan system may never reach 100 percent design air flow, and the design static pressure can be

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Variable Speed Drive Results

Showcase Participant	Mobil Research and Development	Mobil/ Reston
Square Feet	340,000	285,000
Fan Upgrade Cost	$221,000	$130,000
Annual Cost Savings	$105,000	$33,000
IRR	48%	25%
Net Present Value (NPV)	$563,245	$116,477
Annual Energy Savings (kWh)	550,000	550,000
Electricity Load Reduction (kW)	150	140

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reduced. Energy savings can be significant. For example, reducing the static pressure setpoint from 2.5 inches to 1.5 inches can reduce energy consumption by 10 to 35 percent.

EPA provides a software tool for Stage 4 that estimates the expected benefits of fan system upgrades in variable air volume buildings. This software, *QuikFan*, provides estimates of the potential for energy savings and for reducing the size of fan system equipment.

The September *Update* will take a closer look at Stage 5: Improved Heating and Cooling Plants. To learn more about the ENERGY STAR Buildings and Showcase programs, call the Green Lights/ENERGY STAR Hotline at 202 775-6650.

ENERGY STAR BUILDINGS

Making the CFC Phaseout Profitable

Stage 5: HVAC Plant Improvements

To introduce Green Lights participants to the ENERGY STAR *Buildings program, the* Update *is documenting the success of Showcase Buildings participants in each stage of program implementation. This article, the seventh and final in the series, describes Stage 5: HVAC Plant Improvements.*

Stage 5 focuses on upgrades to heating and cooling plants and peripheral equipment. These final upgrades take advantage of the load reductions achieved in Stages 1 through 3; reductions that may allow for the downsizing of heating and cooling equipment.

Cooling Plant Upgrades

Building owners are presently facing the phaseout of chlorofluorocarbon (CFC) refrigerants on January 1, 1996. As required by the 1990 Clean Air Act Amendments, the refrigerants currently used in most centrifugal chillers (CFC-11, CFC-12, and R-500) will no longer be produced and alternatives will be needed. Compliance with these regulations, however, should be viewed as an opportunity to increase the energy efficiency of a building. By implementing the ENERGY STAR Buildings staged approach along with a refrigerant management plan, the phaseout can be profitable. Building owners should prepare for the CFC phaseout by developing a refrigerant management plan that includes a combination of tightening existing systems, recycling refrigerant, upgrading systems, or replacement with more energy-efficient equipment using alternative refrigerants.

At the onset of Stage 5, many upgrades have already been completed and have likely brought about significant reductions in cooling load requirements. Therefore, purchasing a smaller, more energy-efficient chiller can lower equipment costs further. If a replacement is not possible, the chiller can usually be upgraded to use an alternative refrigerant, often still increasing efficiency. At Mobil Research and Development, a Showcase building, three CFC-11 chillers were replaced with energy efficient HCFC-123 chillers. This resulted in an annual energy savings of 990,000 kWh and an annual cost savings of $52,000. Previous ENERGY STAR upgrades resulted in a cooling load reduction of 212 tons. Therefore, Mobil Research and Development was able to purchase chillers smaller than previously required.

STAGE 5 UPGRADES

Showcase Participant	Mobil Research and Development	Mobil/ Reston
Type Of Upgrade	High-efficiency HCFC-123 chillers VSDs on cooling tower fans and chilled water pumps	VSDs on cooling tower fans
Square Feet	340,000	285,000
Upgrade Cost	$405,000	$8,400
Annual Cost Savings	$52,000	$2,400
IRR	13%	29%
Annual Energy Savings (kWh)	990,000	97,000

Heating Plant Upgrades

Approximately 20 percent of all commercial buildings use boilers for space heating. While the combustion efficiency of older boilers is generally between 65–75 percent, inefficient boilers can have efficiencies as low as 40 percent. Poorly operated boilers or those frequently run at part-load conditions can lose even more efficiency. In these situations, the best opportunity for energy savings is a complete system replacement. A move to a newer, energy-efficient boiler means increased heating surface area and improved controls for fuel and air flows over the range of load conditions. A system which includes several small boilers operating in combination, is even better, improving overall efficiency to 90 percent. Upgrading existing boilers can also dramatically improve efficiency. Installing new burners and/or controls can extend the useful life of heating systems and reduce emissions.

In addition to heating and cooling plant equipment, Stage 5 upgrades cover improvements to peripheral equipment. Variable speed drives (VSDs) can be installed on chilled water pumps, hot water pumps, and cooling tower fans, to save energy the same way they do on air handling systems and to optimize pumping configurations, especially if a central plant serves multiple buildings.